Dynamic Properties of the MAX IV Floors

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Introduction

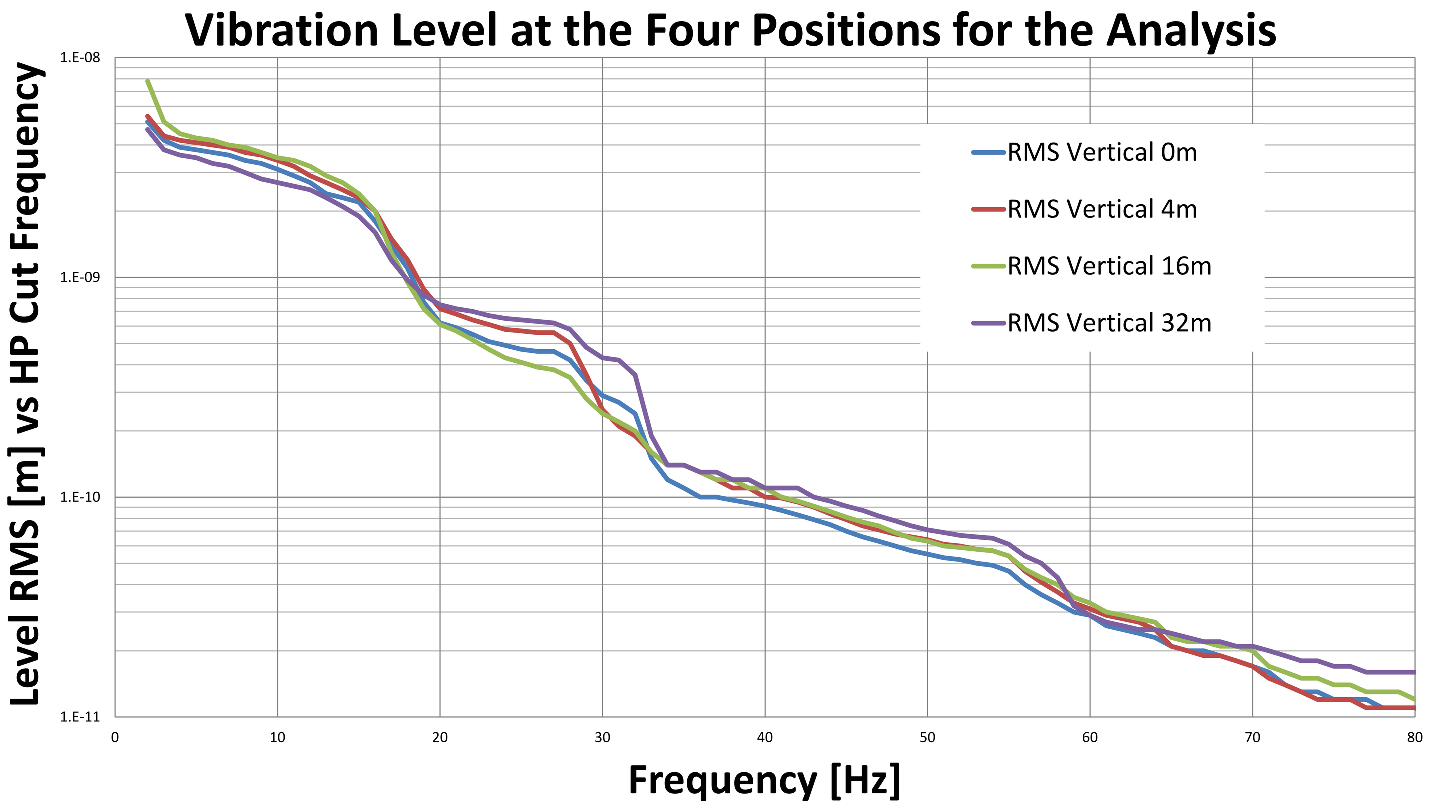
The floors at a synchrotron facility like MAX IV make up the backbone of accelerators and beamlines. The correlations of motions are an important parameter when it comes to the sensitivity to vibrations. The MAX IV floors and the foundation of the buildings are designed to optimize correlation by focusing on stiffness. We present preliminary measurements of the MAX IV floors dynamical properties and summarize the philosophy behind the floor design.

Preliminary Results

Some preliminary measurements were performed on the dynamical properties of the floor at the experimental hall.
The mathematical term Correlation is not very descriptive when it comes to what is the effect of the correlated motions.
In this analysis the relative displacement as function of distance and frequency is presented.

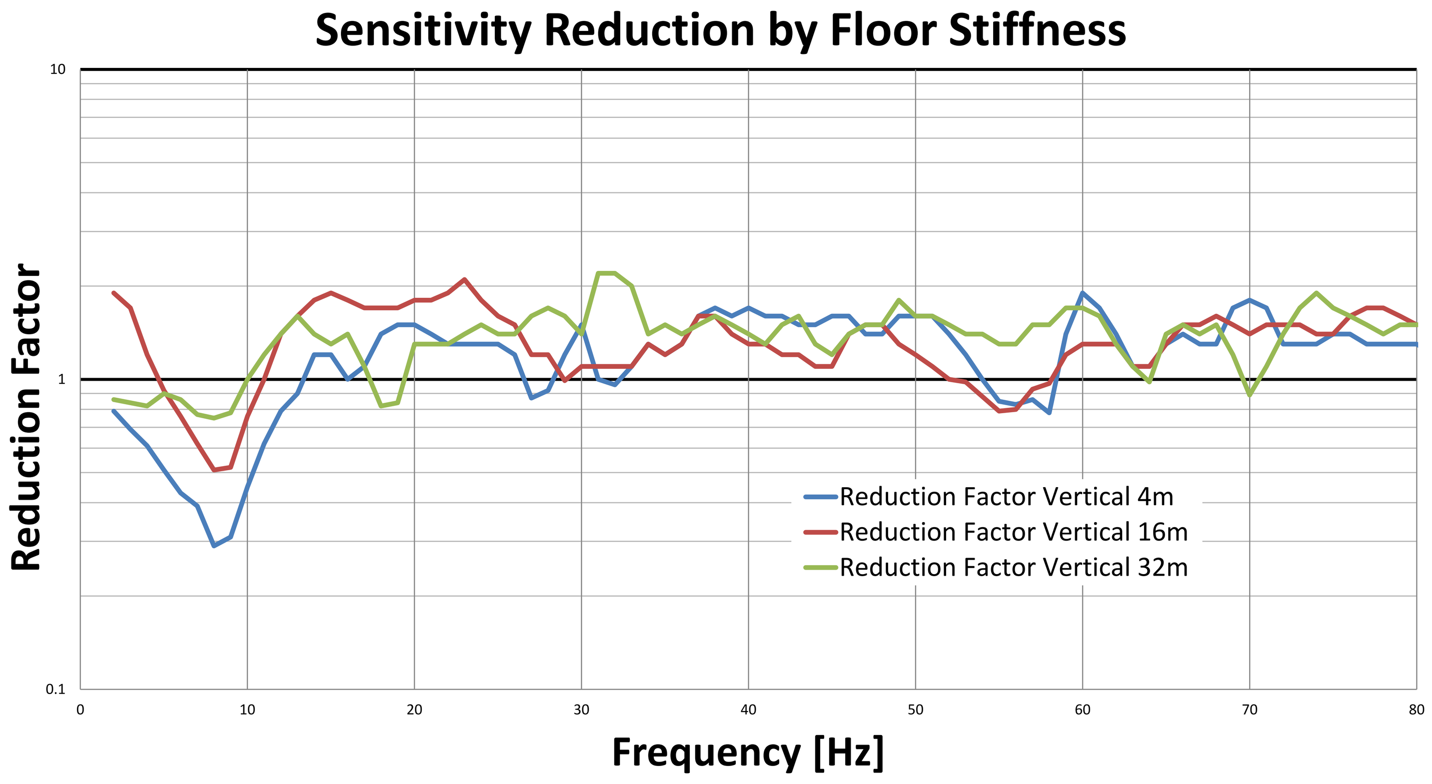
The measurements were done during late afternoon/evening time. Thus the graphs cannot be taken as a general forecast of the real levels in operation. Only the vertical part is presented here.

Vibration Level at the Four Positions for the Analysis



The raw signal from 0m was subtracted from the 4m ,8m and 16m signals in order to get the difference. On the integrated (and logarithmic) RMS scale the difference is not so clear. In stead the difference was normalized (In the frequency domain) to the signal at 0m. The result is a measure of the floors ability to reduce the sensitivity as function of Frequency and Distance:

Sensitivity Reduction by Floor Stiffness



As expected, the reduction factor is best at long wavelengths and at shorter distances. If the displacements are uncorrelated one should expect the factor to be $\sqrt{2}$. (That is if the vibration levels were equal)

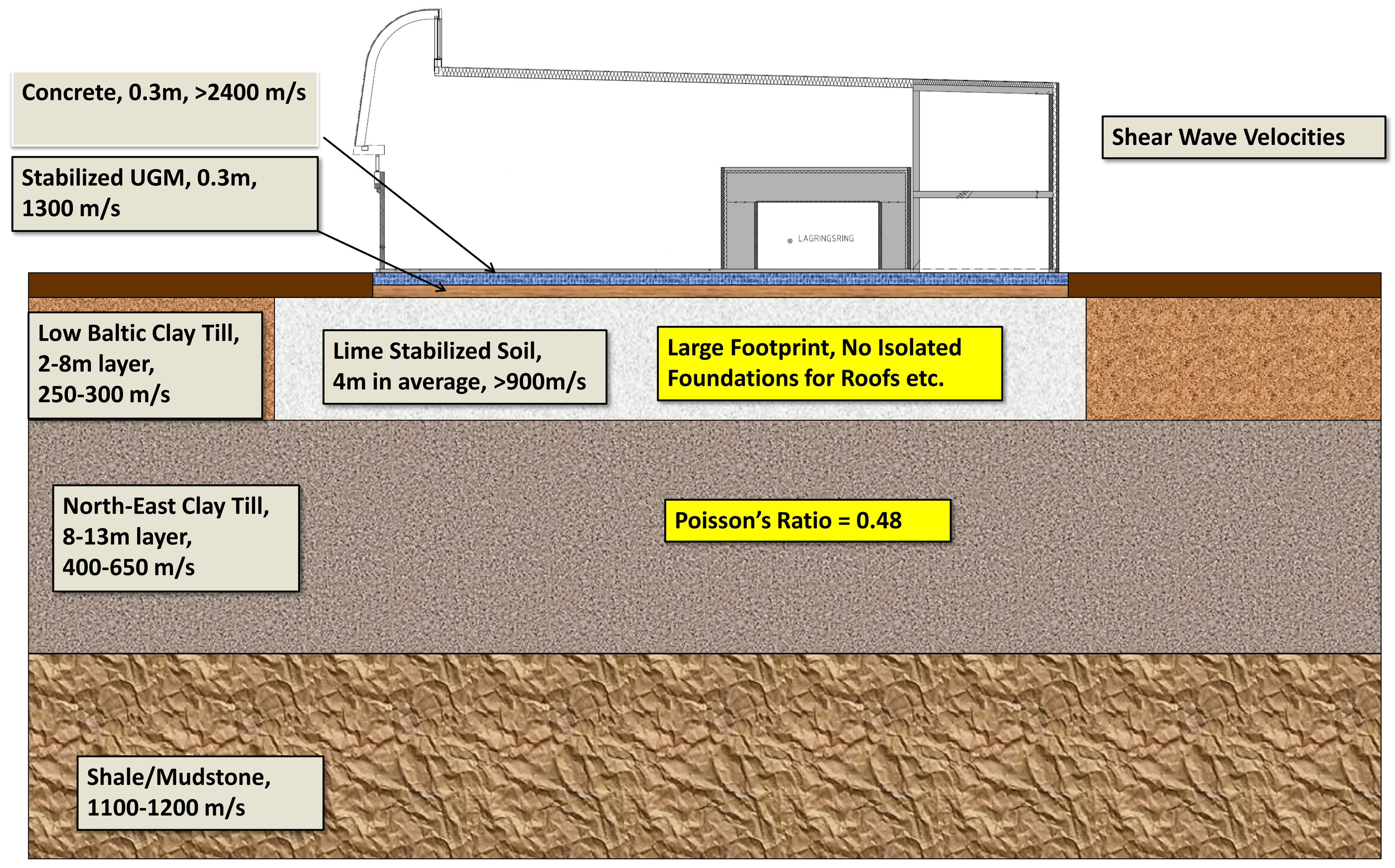
To Come

There is space for improvements to the measurements and the analysis. This will be done within the next 6 months. Also measurements of the storage ring magnet vibrations rather than on the floor will be done. Better sensors and longer measuring periods are needed to get better statistics and less noise.

The curves here could be used to simulate correlated motions of storage magnet units and thus do a more realistic estimation of the amplification factor for the electron beam.

The MAX IV Floor design

Reducing vibrations from the outside world is difficult. The philosophy behind the floor design at the MAX IV Laboratory is to reduce sensitivity to vibrations.
We see the floor as a structural part of the accelerators and beamlines.
Extensive geological and geodynamical investigations were done and various schemes were tested using FEA. We believe that the solution for the MAX IV Floors is the best for the geology at the site with highly over-consolidated clay till and high Poisson's ratio.

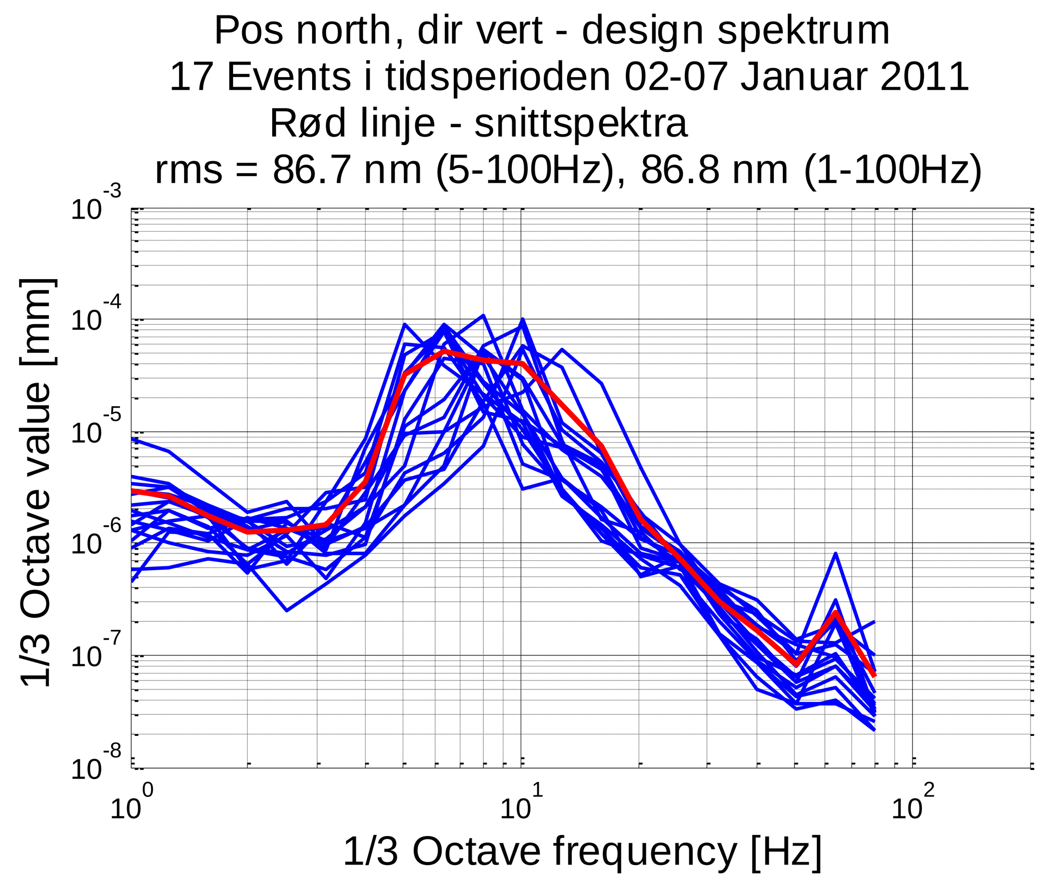


Schematic View of the MAX IV Floor Design including the Underlying Geology. www.ekdahlgeo.se

In order to optimize stiffness for a reasonable cost, the foundation consists of 4m Lime Stabilized Soil (LSS). The volume cost ratio between concrete and LSS is approximately 10.

MAX IV Site Vibration Spectrum

So far it has not been possible to do reliable long term vibration measurements in the new buildings. Green field studies before the construction start, show that the largest contribution to vibrations lies in the range 5-15Hz. The graph is an example shows the averaging over the 17 highest "events" over several days (Vertical) **[1]**. The spectrum is dominated by the soils natural frequencies at the site.



Reducing sensitivity to vibrations

The vibrations of the electron beam depend on the nature of magnet vibrations. If all magnet units in the 3GeV ring at MAX IV are vibrating independently, the amplification factor is 15.
If each achromat is vibrating as a unit, the factor is 3.5. The general vibration goal for MAX IV is 20-30nm RMS f>5Hz. This is based on an assumption of an amplification factor of 10. The more correlated, the less sensitive.
Since the major part of vibrations is low frequency it should be possible to get a good degree of correlation.

References

[1] NGI, Norwegian Geotechnical Institute, "NGI_20110916_Frekvensspektra_jan11_jun11_sept09.pptx"

Equipment:

Wilcoxon 731A/P31 seismic accelerometer and power amplifier system.
24 bit ADC from Data Translation, type DT9837A
Home-build Analysis Software for LabVIEW: "ReadData4Ch_with_FreqDomActions_V2p3.vi"

More information and reports can be supplied by brian.jensen@maxlab.lu.se

The MAX IV Laboratory

The MAX IV Laboratory opened for operation in 1987 (under the name MAX-lab) and is a national laboratory operated jointly by the Swedish Research Council and Lund University. The laboratory supports three distinct research areas: Accelerator Physics, Research based on the use of Synchrotron Radiation, and Nuclear Physics using high energy electrons.

At present three synchrotron storage rings are in operation MAX I-III and each year close to 1000 researchers visit the laboratory to perform experiments. The MAX IV laboratory is also responsible for the build up of the MAX IV facility situated in the Brunnshög area just outside of Lund and approximately 2 km from the present facility.